

## **White Paper**

Analysis and Optimization of the Mechanical Systems for Sustainable Preservation of Collections

Molly Kruckenberg, Montana Historical Society

October 26, 2018

## **Analysis and Optimization of the Mechanical Systems at the Montana Historical Society for Sustainable Preservation of Collections**

Funding from the National Endowment for the Humanities' Sustaining Cultural Heritage Collections program allowed the Montana Historical Society to conduct the work of this project, which occurred from October 1, 2016 through September 30, 2018

### **Activities**

The first step of the project was to create the Environmental Management Team (EMT) to both complete the work of this grant project and for ongoing, meaningful collaboration between facilities, collections and administrative staff. That team was created and consists of:

- Montana Historical Society Staff:
  - Jennifer Bottomly-O'looney, Museum Senior Curator
  - Molly Kruckenberg, Research Center Program Manager
  - Roberta Gebhardt, Library Manager
  - Jodie Foley, State Archivist/Archives Manager
  - Delores Morrow, Photograph Archives Manager
  - Denise King, Centralized Services Program Manager
  - Peter Brown, Historic Architecture Specialist
- State of Montana, Department of Administration Staff:
  - Doug Higgins, HVAC Control System Specialist
  - Mark Hines, Mechanical/Energy Engineer
- Consultants from Image Permanence Institute:
  - Jeremy Linden, Principal Investigator and Preservation Environment Specialist
  - Kelly Krish, Preventive Conservation Specialist

The EMT met in person October 25-27, 2016, at the Montana Historical Society. Representatives from the Montana Historical Society, Montana Department of Administration and the Image Permanence Institute gathered for those three days to gain a better understanding of the operation of the MHS HVAC system and its deficiencies and to understand the effects of the current HVAC system on the long-term preservation of collections. During the meeting, participants reviewed project objectives and methods, documented the configuration of the current HVAC system, determined data logger locations within the HVAC system and diagramed those locations, documented data logger locations in collections areas, installed data loggers in HVAC system, and set next steps for the project.

From October 2016 through September 2017, MHS staff gathered data from the data loggers in the HVAC system and collections storage areas monthly and uploaded that data to the eClimateNotebook online software for analysis. MHS and Montana DoA staff met regularly with IPI consultants via webinar (April 3, 2017; June 8, 2017, and August 17, 2017) to review the data collected. Through these meetings and the data analysis from IPI the EMT determined areas of sub-optimal storage environments for collections. In general, relative humidity was found to be low throughout collections storage areas, due primarily to the humidifying capacity of the HVAC units and the low relative humidity of the natural environment.

Through further analysis of the data collected and review of the HVAC systems at the MHS, IPI consultants concluded that testing operational changes that might affect either environmental conditions in collections storage areas or energy efficiencies was nearly impossible. Although there is

currently a partial Building Management System (BMS) in place, the system provides very limited control over the equipment. Any changes to HVAC settings required a technician to be on site to make alterations to both the current BMS system and/or manually at the unit itself. Although testing operational changes was not an option, the EMT continued to collect and monitor the environmental data throughout the grant period.

The EMT met again in person June 13-14, 2018, at the Montana Historical Society. Representatives from the Montana Historical Society, Montana Department of Administration and the Image Permanence Institute were present. EMT members revisited project objectives and methods; reexamined the air handling units being studied to confirm documentation, downloaded data, and discussed controls for the units; revisited collection storage spaces to confirm documentation and download data; conducted data analysis; and reviewed the final findings from the data gathered.

Following the final in person meeting, consultants from IPI completed analysis of the three mechanical systems studied through this project. A final report of their findings was completed in August 2018 and is included as Appendix A of this report. The highest priority recommendation from the IPI consultants is to upgrade the MHS HVAC units to full BMS controls. Given that recommendation, MHS and the Montana DOA contracted with CTA Architects Engineers of Billings, Montana, to design Direct Digital Controls (DDC) for the HVAC units at the MHS. Kim Beaudry, PE, Mechanical Engineer with CTA, visited the MHS in August 2018 to review and analyze the current systems. The schematic design for DDC were completed in September 2018 and are attached to this report as Appendix B.

MHS staff continue to collect data from collections storage areas using the IPI PEM2 environmental monitors. The data is uploaded to eClimateNotebook and members of the EMT continue to review the data monthly.

### **Goals and Accomplishments**

At the outset of this grant, MHS established six major goals for the project:

1. Create an Environmental Management Team for ongoing, meaningful collaboration between facilities, collections and administrative staff;
2. Gain a better understanding of the operation of our current HVAC system;
3. Understand the effects of the current HVAC system on the long-term preservation of our collections;
4. Define optimal storage environments for MHS collections;
5. Identify opportunities for energy savings; and
6. Identify short and long-term strategies for improving environmental conditions in collections storage areas while being energy efficient.

As the first step of the grant, the **Environmental Management Team** was established in September of 2016. The EMT consisted of representatives from facilities staff from the Montana Department of Administration; collections staff, including curators, archivists and librarians from the Montana Historical Society, and administrators, including program managers and budget personnel from the Montana Historical Society. For the purposes of this project, preservation and HVAC consultants from the Image Permanence Institute were also part of the EMT. The EMT met regularly in person and via webinar/conference call throughout the grant period.

The creation of the EMT has been beneficial to the MHS in regard to management of the environmental controls beyond the scope of this project already. The relationships created between the facilities

management staff and the MHS helped both those charged with managing the HVAC systems and those charged with collection preservation to understand the issues and challenges facing each group. All members of the EMT benefitted from the increased understandings by coming away from the projects knowing the goals of each group, each agency's concerns, the limitations of equipment and staffing, and what is truly practical in the management of the current HVAC systems at MHS. As an example of work beyond this project, facilities staff have worked with MHS collections staff to adjust settings in collections storage areas not studied through this project. MHS has also seen increased responsiveness from the HVAC technicians when environmental issues have arisen.

Through the EMT meeting and consultations with the IPI consultants, MHS curators, archivists, librarians and manager all gained **a better understanding of the operations of our current HVAC systems**. Prior to the project, MHS staff had little interaction with facility staff beyond requesting temperature and humidity setting changes. There was little understanding of how the HVAC systems worked, why environmental swings occurred in different areas of the building, and why changes made to the HVAC systems did or did not work. The expertise of the IPI consultants in bridging the gap between HVAC knowledge and collections care knowledge was invaluable. IPI consultants were able to review the MHS HVAC systems and then explain their operations in a way that made sense to the collections staff involved in the project. Additionally, while MHS has been using IPI's eClimateNotebook for several years, staff did not fully understand the capabilities of the reports and what they could offer for insights into the operations of the HVAC system.

Using the knowledge gained through the relationships of the EMT and the expertise of the IPI consultants, MHS staff gained an **understanding of the effects of the current HVAC system on the long-term preservation of our collections**. As outlined in more detail in the final report from IPI (see Appendix A), the HVAC systems at the MHS are controlled by a mix of pneumatics and Building Management System (BMS) controls. This allows for only limited control of the units, meaning that adjustments to specific areas and for specific times of the day or year are difficult if not impossible to make and require a technician to be on site to make the changes. One of the significant issues identified is higher than recommended temperatures and lower than recommended humidity levels, which has already resulted in some damage to artifact collections (see digital images in Appendix C). Additional humidity issues were identified in storage areas for archival collections. Humidity levels in that area fluctuate, with a low of 25% and an average of 48%. There is concern that fluctuations exceeding the 60% RH level would put the collections in this area at risk. Finally, the art storage area was determined to be at high risk for water damage due to the type of conditioner in the area. The water-based air conditioner in that space is designed for cooling only and is conditioned by domestic cold-water lines, which are susceptible to leaks.

The goals of **defining optimal storage environments for collections** and **identifying opportunities for energy savings** were both hampered by the lack of a BMS and the inability to make on-the-fly adjustments to the temperature and relative humidity settings on the current HVAC systems at the MHS. However, IPI consultants were able to identify two changes to the existing norms for storage environments. Since Montana generally experiences lower levels of humidity than other parts of the country, most of the materials have experienced these conditions previously, so 25% RH can be set as the minimum rather than 30% RH to avoid unnecessary humidification. Also, there may be the opportunity to lower the temperature settings in the winter to better maintain or raise average relative humidity levels.

While we were unable to conduct any testing for conclusive energy savings, the IPI consultants identified three areas where there is potential for energy savings in the future. Specifically, if a BMS can be installed, testing and determining appropriate system shutdowns could reduce energy consumption in each HVAC unit by roughly 33%. Also, rebalancing the HVAC system could help to improve efficiency of the delivery and distribution of air throughout the facility. Finally, with better control of outside air used in the HVAC system, MHS may be able to take advantage of low outside dew points to reduce the need for dehumidification.

The eighteen-month study of the HVAC systems and storage conditions at MHS helped to **identify short and long-term strategies for improving environmental conditions in collections storage areas**, with the potential for future energy efficiencies. The IPI team, with input from the EMT, identified several priorities for improving conditions in storage areas and the operations of the HVAC units. The highest priority strategy identified is to upgrade to full BMS controls of all HVAC units at the MHS to allow for greater ability and ease to test and adjust system operations. In addition, the consultants also recommended the following actions:

- After installation of a BMS, test system shutdowns to determine if energy efficiencies are possible.
- Add additional dataloggers to artifact storage areas to capture data about micro-climates.
- Have a testing and balancing study performed to determine if the HVAC system needs rebalanced to improve air distribution.
- Fix clock and timer issues on the MZ-1 HVAC unit to better control the cooling capabilities of the system.
- Remove all airflow restrictions on return grilles and supply diffusers so that air can move freely throughout the spaces.
- After installation of a BMS, test the use of economizer operations, specifically regarding the use of outside air in the summer months.
- Move the location of the humidification on the AHU4 HVAC unit to better improve humidification capabilities.
- Inspect and possibly clean the ductwork in the collections storage areas to avoid creating a breeding ground for pests, particulates, and mold and to reduce the effects on the collection.
- Insulate the art storage area and install a new mechanical unit in the room below the storage area, for overall improvement to environmental conditions and to lessen the chance of water damage from the current system.

As stated previously, due to the lack of a BMS and the difficulty in making any adjustments to the system, we were unable to test system shutdowns or changes to temperature and humidity settings to determine if any energy efficiencies could be made to the HVAC systems. While this was disappointing, MHS has already moved forward with design plans for the installation of a building-wide BMS. The design plans were completed with partial funding from this grant project and additional funds from other sources. MHS has begun considering funding sources for the implementation of a BMS. In addition to an implementation grant from the NEH's Sustaining Cultural Heritage Collections program, we have identified possible funding from the regional energy company, Northwestern Energy, energy efficiency grant program, as well as from private foundations. Installation of a BMS will depend upon the success of these funding applications.

### **Continuation of the Project**

MHS is committed to utilizing the information gathered through this study and analysis to continue making improvements to both our existing HVAC systems and to the management of environmental conditions in collections storage areas. As stated previously, MHS has already moved forward with design plans for the installation of a building-wide BMS. The design plans were completed in September 2018 with partial funding from this grant project and additional funds from other sources. MHS has also begun exploring funding sources for the implementation of a BMS. In addition to an implementation grant from the NEH's Sustaining Cultural Heritage Collections program, we have identified possible funding from Northwestern Energy's, energy efficiency grant program, as well as from private foundations.

While installation of a BMS will depend upon the success of these funding applications, a few of the other strategies for improving conditions in storage areas and the operations of the HVAC units are straightforward and will be implemented in the near future. These include

- Adding additional dataloggers to artifact storage areas to capture data about micro-climates.
- Remove all airflow restrictions on return grilles and supply diffusers so that air can move freely throughout the spaces.
- Inspect and possibly clean the ductwork in the collections storage areas to avoid creating a breeding ground for pests, particulates, and mold and to reduce the effects on the collection.

### **Long-Term Impact**

There are several long-term impacts that resulted from this grant project. These include the formation of the EMT and the creation of new and improved relationships between MHS and facilities management staff, increased MHS staff knowledge about the operations and management of the current HVAC system and its impact on collections storage environments, and, perhaps most importantly, sound direction and justification for pursuing funding for long-term improvements to the HVAC system and ultimate storage conditions at MHS.

The implementation of an Environmental Management Team has benefited both the MHS and the facilities management staff. All members of the EMT benefitted from the increased understandings by coming away from the projects knowing the goals of each group, each agency's concerns, the limitations of equipment and staffing, and what is truly practical in the management of the current HVAC systems at MHS. The relationships created between the team members has led to better communication and increased responsiveness from MHS staff and HVAC technicians when environmental issues have arisen. The continuation of the EMT will ensure that both future HVAC projects and current HVAC management meet the needs of both groups. Through the EMT meeting and consultations with the IPI consultants, MHS curators, archivists, librarians and manager all gained a better understanding of the operations of our current HVAC systems and the capabilities of eClimateNotebook in understanding the HVAC system impact on collections storage areas. The relationships and understandings created through the EMT as well as the knowledge about HVAC systems and eClimateNotebook will assist MHS in future environmental management projects.

The information gathered by the IPI project consultants throughout the project, that was then compiled into the final consulting report, have provided sound direction and justification for pursuing funding for long-term improvements to the HVAC system and ultimate storage conditions at MHS. Without this third-party direction and justification, pursuit of additional funding from federal and private sources would be difficult or impossible. This grant project will allow MHS to move forward with significant, long-term improvements to our HVAC system that simply would have been possible otherwise.